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REDUCED APPLICATION ENERGY CLOSURE

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[0001] This application claims the benefit of United States Provisional Patent Application Serial No. 60/401,544, filed August 7, 2002.

[0002] The present invention generally relates to closure caps for sealing food or beverage containers, wherein the closure includes a plastic shell with an integral tamper-indicating band. More particularly, the present invention relates to closure caps with tamper-indicating bands that can be initially applied to the container with a reduced potential for premature breakage of the bridges that connect the closure shell to the tamper-indicating band.

BACKGROUND OF THE INVENTION

[0003] Closures having tamper indicating features are well known in the art and have been commonly used for a wide variety

of products. Closures for use in food and beverage containers include a closure shell formed of metal, plastic or both metal and plastic.

[0004] A tamper indicating feature commonly used with "screw-type" plastic closures, for use in association with plastic containers, is one where the closure includes a cylindrical band integrally attached by a plurality of frangible bridges to the bottom of the closure shell. The band is located beneath a retaining flange or bead on the neck of the container. When the closure is unscrewed, the retaining flange or bead holds the tamper indicating band, causing the frangible bridges to break, thus releasing the closure shell from the band (which remains with the container.)

[0005] One problem often encountered with closures and tamper evident bands of this type is premature breakage of the bridges during initial application of the closure to the container. During initial application, the tamper indicating band must be forced over the retaining flange or bead of the container. As the tamper indicating band is forced over the flange, it is radially stretched and the applied downward force is translated to and retained by the band as elastic energy.

[0006] The elastic energy retained in the band is released when the band has cleared the flange and is returned to its original shape. However, if the elastic energy retained in the band is too great, the release of such energy can result in premature bridge breakage. Naturally, a band with prematurely broken bridges undermines the primary function of the band,

which is to assure the consumer that the contents of the container have not been tampered with.

[0007] One solution to the potential problem of premature bridge breakage during application has been to apply heat, typically in the form of steam, to the closure during application. The steam sufficiently softens the plastic material of the closure as it is forced over the retaining flange of the container and, thus, reduces the force needed to apply the closure.

[0008] While heating the closures during application has worked satisfactorily, it may not always be desired. Heat treatment of the closures may add to the cost of the packaging process. Heat treatment of the closures also requires careful control of the temperature so that the applied heat does not negatively affect the integrity of the closure and/or the tamper indicating band. Moreover, the use of heat may not cause an identical effect in the application process of closures, since not all closures of a given lot are exactly identical and may not be identically affected by the temperatures used to heat the closures. As a result, heat treatment may introduce unintended variances, even in closures of the same lot or manufacturing run.

[0009] Thus, there is a need for a closure cap with a depending, cylindrical tamper indicating band that can be applied to the container with a reduced potential for premature bridge breakage, either with or without heating during closure application. There is also a need for a band that minimizes

this potential, yet maximizes the ability of the band to remain on the container during unscrewing of the closure cap. It would also be desirable, in certain cases, to provide a closure with the aforementioned properties without having to heat the closure during the application process. These and other needs of the industry are addressed by the closure of the present invention.

SUMMARY OF THE INVENTION

[00010] In one aspect, the present invention is directed to a plastic closure cap having a shell, including an end panel and a downwardly depending skirt. The closure cap includes a cylindrical band attached to the terminal end of the skirt by a plurality of frangible connectors. The cylindrical tamper-indicating band includes an inner surface, outer surface and a top surface that is downwardly tapered in the direction of the outer surface. The inner surface includes a bead for contacting a retaining bead on a container finish and a outer surface. The outer surface includes a groove or notch therein, that is generally axially oppositely disposed relative to at least a portion of the band bead.

BRIEF DESCRIPTION OF THE DRAWINGS

[00011] Figure 1 is a partial view of a plastic bottle, the open end of which is secured with a plastic closure cap embodying the present invention;

[00012] Figure 2 is a cross-sectional view of the closure cap of Figure 1;

[00013] Figure 3 is an enlarged cross-sectional view of the closure cap embodying the present invention;

[00014] Figure 4 is a partial cross-sectional view of the skirt portion and tamper-indicating band of a closure cap embodying the present invention;

[00015] Figure 5 is a partial, enlarged cross-sectional view of the closure cap during application of the cap over the open mouth of the beverage container;

[00016] Figure 6 is a partial cross-sectional view of one embodiment of a closure with a tamper-indicating band embodying the present invention;

[00017] Figure 7 is a perspective view of a closure with a band embodying the present invention;

[00018] Figure 8 is a partial perspective view of the closure with the band of Fig. 7;

[00019] Figure 9 is a cross-sectional view of a tamper evident band, taken along line 9-9 of the closure shown in Fig. 7; and

[00020] Figure 10 is an enlarged cross-sectional view of a bridge on the tamper evident band shown in Fig. 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[00021] Turning now to the drawings, Figure 1 shows a closure cap 10 embodying the present invention, secured over the mouth of a container, such as bottle 50. Closure 10 can be made of any suitable thermoplastic material, examples of which will be well known to those of skill in the art, and are discussed in greater detail below. Preferably, closure 10 is made of polypropylene or copolymers thereof. Closure 10 is preferably formed by injection molding or by other molding operations which

will also be known to those of skill in the art. Closure 10 is suitable for use with containers, such as bottle 50, that are made of polyethylene terephthalate (PET) or other known plastic materials.

[00022] As shown in Figs. 1 and 2, closure 10 includes a shell 14 having an end panel 16 and a skirt 18 that depends from panel 16. Inner surface of panel 16 can also be provided with a full panel liner or gasket made of a thermoplastic composition such as, but not limited to, a thermoplastic elastomer. The liner or gasket provides a hermetic seal with the finish 56 of container 50, and may also provide other desirable properties such as oxygen barrier properties. Closure 10 also includes a cylindrical tamper-indicating band 20, which is preferably integrally connected to the terminal end 22 of skirt 18 by circumferentially spaced bridges 24. Alternatively, tamper-indicating band 20 may be an extension of skirt 18 separated from skirt 18 by a semi-continuous slit or line of weakening between band 20 and skirt 18.

[00023] Turning now to Fig. 2, neck or finish 56 of container 50 includes a plurality of partial external threads 58 circumferentially and axially spaced on finish 56. Finish 56 further includes an annular flange, referred to herein as finish bead 60, spaced axially downwardly from threads 58. As shown in Fig. 2 and Fig. 5, finish bead 60 can have a downwardly sloping top surface 62 and a bottom surface 64. In one preferred embodiment, bottom surface 64 is substantially horizontal. Alternatively, surface 64 may be upwardly sloped.

[00024] In any event, bottom surface 64 provides an abutment for the tamper-indicating band 20 of closure 10, as generally shown in Fig. 2 and described in greater detail below. The outside diameter of finish bead 60 is greater than the outside diameter of threads 58. Finish 56 may optionally include a support ledge 52 spaced below finish bead 60. Support ledge 52 typically provides an area for holding container 50 during handling and filling and may also provide a stop for the tamper-indicating band 20 of closure 10 once separated from shell 14. Support ledge 52 is also a circumferential flange with an outside diameter greater than that of finish bead 60.

[00025] Turning now to closure 10, as shown in Figs. 2 and 3, inner surface 26 of closure 10, and more specifically shell 14, includes an external thread or a plurality of external threads 28. Preferably, inner surface 26 includes at least two external threads, each spanning at least approximately 180° of the total circumference of closure 10. In one embodiment, the leads may span approximately 270° of the total circumference of closure 10. A thread arrangement of this type will be recognized by those in the art as a so-called "2-lead thread." Alternatively, thread 28 may be a single lead, a 3-lead or a 4-lead thread, or any other suitable multi-lead thread. In any event, threads 28 cooperate with threads 58 of container finish 56 during initial application of closure 10 onto container 50, and during opening and closing of container 50 by the consumer. In particular, grooves 66 defined by threads 58 on finish 56 (Fig. 5) receive threads 28 of closure 10.

[00026] As shown in the Figures, skirt 18 terminates in a substantially horizontal terminal end portion 22. As described above, and best seen in Fig. 3, skirt 18 is integrally connected to tamper-indicating band 20 by a plurality of connectors or bridges 24. Bridges 24 are circumferentially spaced around closure 10. Top portion of bridge 24 is connected to terminal end portion 22 of skirt 18. The bottom of bridge 24 is connected to the top of band 20.

[00027] Bridges 24 may be uniform in width from top to bottom (i.e., from terminal end 22 of skirt 18 to band 20). Alternatively, bridges 24 may taper either upwardly or downwardly, thus having a reduced width either near the top or the bottom thereof. As shown in the cross-sectional view of Fig. 10, bridges 24 may be in the shape of a trapezoid. The trapezoidal shape of the bridges may be particularly advantageous where closure 10 is molded and the mold is one that includes two mold neck rings that move along a single axis, as shown for example in Fig. 10, where Y represents the axis of movement and X represents the porting line. In this case, the shape of the bridge results in a uniform bridge configuration of uniform shape and area that is suitable for mold opening. Preferably, all of bridges 24 have the same cross-sectional shape and area. Bridges that are uniform (i.e., have the same cross-sectional shape and area) also reduce the incidence of bridge breakage on application by promoting equal distribution of the application forces. As all bridges have the same stiffness uniformly, the bridges experience equal stresses,

since the area of each bridge is the same.

[00028] Equalizing the stresses and strains on the bridges minimizes the side loads acting on band 20 as closure 10 is removed from the container by the consumer. Minimization of side loads and unequal loads, in turn, reduces the likelihood of a "tire-off" condition. A "tire-off" is a condition where the closure tamper band 20 moves over the finish retaining bead 60.

[00029] In general, the cross-sectional area of bridges 24 must be large enough to allow filling of band 20 during the molding process. A molding injection gate for a closure of the type shown is generally located in the upper shell portion of the closure and the plastic material flows through the bridges to form the tamper band. Too small of a bridge area can lead to poorly formed closures. Also, since the injection molded closures are commonly ejected by pushing on the bottom of the tamper band 20, the bridges that connect the tamper band 20 to upper shell 14 must be strong enough to withstand the ejection forces. The bridge area must also be large enough to handle the stress generated during closure application to the finish to discourage bridge breakage, but small enough to assure bridge breakage and tamper band separation during removal. Stress in the bridges during application is, at least in part, a function of the bridge shape, application speed, tamper band geometry and material properties including flexural modulus, tensile strength at yield, and impact strength, discussed in more detail below. For example, where closure 10 is made of a material of relatively lower tensile strength, the cross-sectional area of

the bridge may be increased as compared to a closure made of a material with a relatively high tensile strength. The stresses in bridges 24 during removal are a function of the same factors with the exceptions of speed and impact strength, since removal speeds are significantly lower than application speeds.

[00030] Turning now to tamper-indicating band 20, as shown in Figs. 2 and 3, tamper-indicating band 20 is provided as a ring, including top surface 34, bottom surface 36, inner surface 38, and outer surface 40. With reference to the Figures, it will be appreciated that top surface 34 refers to portions 46 of the band 20 located between and interrupted by windows 32, described below. Where the band does not include windows 32, top surface 34 will be continuous around the entire circumference of band 20. Also, as used herein, the terms inner and outer surfaces refer, respectively, to locations that are closer and more distant to and from central axis 42 (Fig. 3) of closure 10.

[00031] Tamper-indicating band 20 and the terminal end of skirt 18 define a circumferential gap 44 interrupted by frangible bridges 24, described above. As shown in Fig. 3, gap 44 is not uniform in height around the circumference of closure 10. In particular, gap 44 between band portions 46 defines apertures or windows 32. Bridges 24 connect tamper-indicating band 20 to skirt 18 within windows 32. Band portions 46 of tamper-indicating band 20 provide areas where band 20 will abut skirt 18 to assist in removal of closure from the mold core during manufacture and/or during placement of the tamper-indicating band 20 during application. Windows 32 allow for an

increased bridge length and for passage of fluid (i.e., "drain" or "washout") during filling operations.

[00032] Continuing now with Fig. 4, as shown in cross-section, the top surface(s) 34 of band portions 46 are uniformly downwardly tapered or angled in the direction of outer surface 40. In accordance with the present invention, angled top surface 34 reduces, in part, the force required during application of closure 10 to container 50. Specifically, as band 20 is radially stretched during application, contact between top surface 34 and terminal end 22 of skirt 18 is increased as compared to the contact that would take place between a substantially horizontal upper surface or surfaces and terminal end 22 of skirt 18. This results in a reduced potential for early bridge breakage, because band 20 rotates as shown in Fig. 5.

[00033] The angle, shown in Fig. 4 as indicated by reference numeral 48, may be any angle that is greater than 0°, as any degree of tapering will assist in the reduction of application forces. More preferably, however, angle 48 can be approximately 6° or greater. In one preferred embodiment, particularly for (but not limited to) closures, having a 43 mm diameter, angle 48 is approximately 15°. Top surface 34 may be angled in an amount greater than the 15° described above. However, it has been discovered that angles substantially greater than 15° may negatively affect removal of closure 10 from the mold core during manufacture. Specifically, an top surface having an angle substantially in excess of 15° may result in damage to

tamper-indicating band 20 during core removal.

[00034] As shown in Fig. 4, inner surface 38 and outer surface 40 are contoured. Inner surface 38 includes circumferential inwardly extending band bead 70 which extends or protrudes inwardly toward the central axis 42 of closure 10. Turning briefly to Fig. 2, when closure 10 is secured to container 50 after initial application, band bead 70 is below finish bead 60. Upward movement of band bead 70 during unscrewing of closure 10, will cause the top of band bead 70 to abut against the bottom surface 64 of finish bead 60, thereby restricting further upward movement of band 20. It is this resistance to band bead 70 by finish bead 60 during uncapping by the consumer that causes bridges 24 to stretch and eventually break, leaving tamper-indicating band 20 around neck 56 of container 50, while releasing shell 14 from band 20.

[00035] As further shown in Fig. 4, outer surface 40 is also contoured and includes a groove or notch 74. Accordingly, as used herein, the term "notch" includes a concave, smooth, groove in surface 40, as shown in Figs. 7 and 8. While a smooth groove of the type shown in Figs. 4, 7 and 8 is preferred, notch 74 may be provided as a less gradually curved and more angled cut out in surface 40. Notch 74 is optimally positioned on outer surface 40 so as to minimize application forces (i.e., the force needed to properly apply and secure closure 10 to container 50). In particular, notch 74 is preferably generally axially oppositely disposed relative to at least a portion of band bead 70. Notch 74 may be formed during the molding process. It may

also be formed by removing a portion of material from outer surface 40.

[00036] Shown in Fig. 6, is one illustrative, non-limiting example of a 43 mm closure. In the embodiment of Fig. 6, notch 74 has a depth of approximately 0.02 inch (as measured from the outer surface 40 and represented by the distance X_5.) The center of notch 74 is approximately 0.06 inch from bottom surface 36 (as identified by Y_6, and where X_4 is approximately 0.03 inch and radius R_3 is approximately 0.05 inch). This is the preferred depth and location of notch 74 for certain closures, including those made of impact copolymers of the type described below. For closures made of other materials, such as the polypropylene homopolymers, or other materials having, for example, a higher tensile strength, the depth of notch 74 (as also indicated by X_5) may be smaller, such as, but not limited to, 0.01 inch with the center of notch 74 being substantially as shown in Fig. 6.

[00037] The approximate dimensions set forth above are the preferred dimensions for a band of the type shown in Fig. 6, having an overall height (the sum of Y_2 and Y_5) of approximately 0.15 to 0.16 inch, a band bead 70 having a diameter Ø of approximately 1.6 inch at a distance of approximately 0.02 to 0.03 inch from surface 38 (as shown by X_2). Band bead 70 may further have a downwardly sloping top at an angle of approximately 20 degrees located at a height of approximately 0.07 (the sum of Y_3 and Y_5 in Fig. 6), band 20 having a width of approximately 0.05 inch across surface 34 (shown as X_1 in Fig. 6) and approximately 0.04 inch across surface 36 (shown as X_3 in

Fig. 6). Other preferred dimensions for band 20 of a closure of the type shown in Fig. 6 are distance Y_1 of approximately 0.16 inch, a distance Y_4 for band bead 70 of approximately 0.02 inch, a distance Y_5 of approximately 0.02, and R_6, R_7 of approximately .02 inch, R_5 of approximately 0.02 inch, R_1 of approximately 0.01 and R_2 and R_4 of approximately 0.04 and .02, respectively.

[00038] As indicated, closures of the present invention may preferably be made of polypropylene homopolymers or copolymers. In one embodiment, closure 10 may be made of a medium or high impact polypropylene copolymer. The copolymer may or may not include a nucleating agent. Where it is desired to apply the closure without steam, an impact copolymer having an Izod Impact notched at 23°C equal or greater than 1.8 ft.-lb./in., a tensile strength at yield of approximately 2,900 to 3,700 psi, a flexural modulus of approximately 130,000 to 160,000 psi and melt flow index of approximately 10 to 22.

[00039] In another embodiment, closure 10 may be made of a polypropylene homopolymer. The homopolymer may or may not include a nucleating agent. The homopolymer may have an Izod impact at 23°C of approximately 0.6 to 2.0 ft.-lb./in., tensile strength at yield of approximately 4,400 to 5,700 psi and a flexural modulus of approximately 200,000 to 300,000 psi.

[00040] For different sized closures, these mechanical properties may differ.

[00041] With reference to Fig. 4, it will be appreciated that the surfaces 38 and 40 are not entirely parallel to one another, and that the different contour of surfaces 38 and 40 define a

band 20 that is non-uniform in thickness from top surface 34 to bottom surface 36. This results in areas of reduced thickness. In one embodiment, the thickness of band 20 may be at a minimum near the region of the top plane of band bead 70, which region is generally designated by reference numeral 78 in Figs. 4 and 5.

[00042] As will be recognized by those of skill in the art, application of a closure to a bottle or container finish requires combined turning and downward force of closure 10. In order for closure 10 to be correctly secured to bottle finish 56, band bead 70 of closure 10 must clear finish bead 60 on bottle finish 56. As discussed above, the axial downward force applied to closure 10 during the application process translates into elastic energy that is stored in tamper-indicating band 20. The elastic energy stored in tamper-indicating band 20 during application is at a maximum when the band is fully stretched. Stated differently, the elastic energy stored in tamper-indicating band 20 during application of closure 10 is at a maximum when band bead 70 is passing over finish bead 60, as shown in Fig. 5.

[00043] Angled top surface 34 and contoured outer surface 40 each independently can provide reductions in the force required to apply closure 10 to container 50. However, the combination of contoured outer surface 40 with notch 74, angled top surface 34, and location of notch 74 generally axially oppositely disposed with respect to at least a portion of band bead 70, provides a further improved tamper-indicating band 20 with

reduced band mass, which results in a greater reduction of the force required to expand band 20 over bottle finish 56 (in particular, finish bead 60) during application. The reduced mass and the positioning of notch 74 on outer surface 40 minimize stored elastic energy, thereby optimizing the application process. Angled upper surface 34 leads to less vertical force required to apply closure 10 which leads to less stored elastic energy in band 20. When combined with the reduced mass of band 20, the potential for premature bridge breakage is reduced.

[00044] A closure made in accordance with the present invention not only provides an optimization of the application force required to apply closure 10 to container 50, but also optimizes the removal force required during unscrewing of the cap by the consumer. Closure 10 of the present invention minimizes the application force required during the application process, while at the same time maximizes the removal force required for the tamper-indicating band 20 to serve as an indicator of non-tampering. The maximization of the removal force substantially ensures that tamper-indicating band 20 cannot simply be slipped off of finish bead 60 of container neck 56.

[00045] Another advantage of closures of the type described above is that, if desired or required, they can be more easily applied to containers 50 without the use of steam or heat to soften the plastic material of closure 10 and specifically tamper-indicating band 20. This results in a package that is

less expensive to manufacture. In addition, elimination of heat and/or steam results in less variation between manufactured closures and less potential for deformation of tamper-indicating band 20, which could impair its tamper-evidencing function.

EXAMPLE

[00046] 43 mm Closures made of an impact polypropylene copolymers of the type described above (and referred to below as A), and 43 mm closures made of polypropylene homopolymers of the type described above (and referred to below as B), both embodying the present invention, were compared to standard closures (referred to below as "standard") made of polypropylene homopolymer which did not include an angled top surface 34 or notch 74 in outer surface 40. The standard closures included a substantially vertical outer surface 40 and a substantially horizontal top surface 34. In all other respects, the closures compared were substantially identical. Both closures A and B included a 15° angled top surface. Notch in closure A had a depth (as indicated by X_5 in Fig. 6) of approximately 0.02 inch, while notch in closure B had a depth of approximately 0.01 inch.

[00047] Closures were applied to a simulated bottle finish which simulates an A-bead type bottle neck according to ISBT standard drawing number PCF-43P-1. The closures were at room temperature and were applied at a speed of 5 inches per minute in a room temperature environment without heat or steam applied to the closure band or shell. The force required to correctly apply and secure the standard closure and the closure embodying the present invention were measured using an Instron™ device and

compared. The results are reported below in Table I. As will be seen from Table I, the force required to apply closures embodying the present invention were less and, in some examples, approximately 40% less than the force required to apply the Standard closures.

TABLE 1

	Standard (lbs.)	A	B
1	95.5	60.2	70.8
2	95.0	60.8	72.1
3	92.3	60.1	69.6
4	85.9	58.3	69.6
5	95.1	59.5	71.4
6	100.1	61.1	70.1
7	93.8	57.6	71.5
8	91.5	57.8	71.0
9	93.2	58.6	71.6
10	89.0	57.7	69.5
Average	93.2	59.2	70.7
Maximum	100.1	61.1	72.1
Minimum	85.9	57.6	69.5

[00048] Closures with bands 20 of the type described above also enhance removal of closure 10 from the molds of the tooling. To eject or strip a closure 10 from a mold, the ejection force is transmitted through the lower base plane of the band. The stiffness of the band must be sufficient to strip the band bead from the mold core and sufficient to strip the closure shell from the mold core without collapse or distortion of the band. In the present invention, closure 10 is stripped from the mold by pushing on the bottom of the band. It has been

determined that a 15° angle on top surface 34, as described above, would produce the most reduction in application forces, while still allowing good support for closure stripping during molding. Closure band swings or moves through 15° angle, thereby allowing band bead 70 to clear core and then impart a force to closure 10 to strip it from the mold core.

[00049] The present invention has been described in the context of a preferred embodiment. It will be apparent to those skilled in the art, however, that modifications and variations therefrom can be made without departing from the spirit and scope of this invention.